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AN EXPLANATION OF THE SHORT LIFE OF FROSTED LAMPS.[1]

By Edward P. Hyde.

It has long been recognized that the useful life of a frosted incandescent lamp, taken to 80 per cent of its initial candlepower, is only a little more than one-half the life of a corresponding plain-bulb lamp. The only explanation which has been advanced, so far as the writer knows, is that the temperature of the frosted lamp is higher, due to the increased absorption by the bulb, and that therefore the lamp reaches any given point in its life, e. g. the 80 per cent point, in a shorter time than that required for the corresponding plain bulb lamp.

Without entering, at present, into a discussion of the possible temperature effects, it is sufficient to notice that if the shortened useful life can be attributed to this cause, it is very probable that, due to the same cause, the total life of a frosted lamp up to the time when the filament burns out would also be very much less than that for the plain lamp. On the contrary, the writer has recently been informed by Mr. S. E. Doane, chief engineer of the National Electric Lamp Association, that numerous tests made at the engineering laboratories of the Association indicate that if the life is taken to the time when the filament burns out, the average life of frosted lamps is the same as that for plain lamps.

It would therefore seem that some other explanation than that of the effect of temperature must be sought. A possible explanation of the phenomenon recently occurred to the writer, and was subjected to a test which showed conclusively that at least a large part of the effect, if not the entire effect, could be accounted for by the proposed explanation. A complete discussion of the investigation, with the detailed numerical results obtained, will be published shortly in an extended paper on spherical reduction factors and on the effect produced by plain and frosted bulbs of various shapes on the distribution of light around filaments of different forms. It was thought desirable, however, on account of the general interest in the question of the short useful life of frosted lamps, to publish this preliminary note outlining the explanation of the effect.

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[1] Printed in the Electrical Review, Apr. 6, 1907, p. 556.

If we consider the case of a new plain bulb lamp, a certain small percentage of the total flux of light emitted by the incandescent filament is absorbed by the glass envelope surrounding the filament. When the lamp is frosted, a relatively large part of the light which in the plain bulb would pass through the outer surface of the bulb is diffusely reflected back through the glass. In this way a relatively large part of the total flux of light passes through the glass more than once, and so the frosted bulbs show an absorption about 5 per cent greater than that for the plain bulbs.

Now the actual absorption coefficient of glass is quite small, so that it is readily seen that if in any way the absorption coefficient is increased appreciably the apparent absorption due to frosting would be increased greatly. This is what happens when with increasing life the strongly absorbing carbon film is deposited on the inside of the bulb. The effect is the same as if the absorption coefficient of the glass had been increased greatly. In the case of an old plain lamp all the light passes through the carbon film once, a small percentage passes through twice, a still smaller percentage three times, and so on. When the lamp is frosted, the percentage that passes through more than once is very much larger, and so the carbon film has an opportunity to absorb a much larger percentage of the total flux. According to this theory, although at any time the filament in the frosted bulb may be emitting the same total flux of light as that emitted by the filament in the plain bulb, the absorption of light in the carbon film is much greater in the one case than in the other, and so the apparent intensity of the frosted lamp at any time during life is less than that of the plain lamp, the difference in intensity increasing with the number of hours the lamps have burned.

In order to test the hypothesis in a rough way a frosted spherical diffusing globe was mounted on the photometer bench. At first a new 4 candlepower lamp, whose intensity was known, was placed inside the globe, and the apparent absorption of the globe was measured. Then an old 4 candlepower lamp, on the inside of whose bulb a very perceptible deposit of carbon had formed, was substituted for the new lamp. Measurements on this lamp showed a much larger apparent absorption of the frosted globe. Then the new lamp was coated with a layer of lacquer which absorbed some of the light, and a third determination of the absorption of the globe was made. As before the apparent absorption was greater than with the bare lamp.

Although in this way the presence of the effect was plainly noticeable, no quantitative results could be obtained because the conditions were quite different from those existing when the bulb of the lamp is frosted. On account of the small size of the neck of the diffusing globe compared with the diameter of the globe, the largest lamp that could be used filled only a relatively small part of the inside of the globe, and so of the light diffusely reflected back by the frosted globe only a part passed through the lamp bulb. Therefore the magnitude of the effect measured in this way was necessarily small compared with that which would occur with ordinary frosted lamps.

In order to make a quantitative determination of the effect, 10 comparatively new lamps and 12 old lamps that had dropped to 80 per cent in candlepower were carefully measured for mean horizontal and mean spherical candlepower. They were then sent to a lamp factory and frosted by the acid process, care being exercised to see that the frosting was as nearly uniform for the different lamps as it was possible to obtain. The lamps were then returned to the Bureau of Standards and measured. The new lamps were found to have decreased in mean horizontal intensity by about 4 per cent on the average, the individual lamps agreeing among themselves to within less than 2 per cent. On the other hand, the older lamps were found to have decreased in mean horizontal intensity by 18 per cent, or 14 per cent more than the new lamps. In other words, the apparent absorption of the frosting was approximately 4½ times as great for the old lamps at the end of their useful life as for the new lamps. This means that if we were to assume no difference in the physical or mechanical properties of plain and frosted lamps, a lot of plain lamps which would decrease 20 per cent in candlepower in a definite number of hours, would in the same number of hours decrease approximately 32 per cent if they were first frosted. The useful life of the frosted lamps to 80 per cent of initial candlepower would be about 60 or 70 per cent of the useful life of the plain lamps, a value in approximate agreement with that commonly accepted. This shows that whatever effects may be produced in the lamps by frosting them, the mere absorption by the deposited carbon film as explained above is sufficient to account for a decrease in useful life of about 30 or 40 per cent.

A single set of measurements of mean spherical intensity indicated that the new lamps had decreased about the same in mean spherical candlepower as in mean horizontal, whereas the old lamps had decreased several per cent more in mean spherical intensity. This is probably due to the uneven distribution of the carbon on the inside of the bulb.

The following experiment has been planned to determine whether there are any other elements entering than that of the increased absorption of the carbon film due to internal reflections. A large number of carefully selected lamps will be accurately measured, of which 20 lamps will be burned to the "peak" point in the curve, 20 more to a point corresponding to about 60 per cent of the normal useful life of the lamps, and 40 more to the end of their useful life, measured to the 80 per cent point. Twenty lamps will not be burned at all. All of the lamps, except 20 of those at the end of their useful life, will now be frosted at the same time and by the same process, and then all will be burned until the filaments break. In this way different points in the life curve can be reached by different paths. Thus, for example, it will be interesting to note whether the 20 lamps frosted at the end of their useful life will have the same average value as the 20 lamps frosted initially and then burned for a number of hours corresponding to the average useful life of the plain lamps. In this way it is hoped to determine whether any other elements enter to partly account for the relatively short useful life of frosted lamps.

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